On the Wild Rice, *Oryza sativa* var. *spontanea* ROSCHEV., Collected at Babat, East Java, Indonesia

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Introduction

During the period from June to July in 1981, the writer was sent to Indonesia for research on agricultural practices under the project, designated as "Ecological Biology and the Promotion of Tropical Primary Industry", supported by a grant from the Ministry of Education, Science and Culture, Japan. Rice cultivation in East Java was studied from several agricultural viewpoints.

Due to the great importance of rice as a food stuff, a large amount of work on rice from different viewpoints has been reported. However, on many points more extensive investigations are required in order to solve the interesting but highly complex problem of its origin and the history of transformation from a wild state into the cultivated crop plant of our time. To throw more light on this problem by a wide range of workers will contribute to the improvement of rice in the future.

Distribution and taxonomical reports on various *Oryza* species have been published by many workers[1,2,3,4,8,9]. Incidentally, one strain of wild rice was found and collected in East Java during this scientific tour. In the present paper, the records of identification, habitat and morphological characters are briefly reported. This data might be of assistance to researchers on the origin and genetic analyses of rice.

Materials and Methods

Plants belonging to the wild species of rice were found during the trip on July 15, 1981. The locality and habitat were recorded in detail. The seeds were collected and used for morphological investigations.

Measurements for morphological studies of grains were done for length, width and thickness of unhusked and husked grains. Thirty grains were used for the measurement. The measurements were done at the largest position of the respective characters. Calculations were done for determining the ratios of length to width, of length to thickness, and of width to thickness, for comparative values on morphological characters of unhusked and husked grains. Moreover, the following 6 characters of unhusked and husked grains were illustrated by the area (=length×width) and volume (=length ×width×thickness) for unhusked and husked grains, the area and volume quotients

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(=ratio of value of husked to value of unhusked grains).

The correlation between practical values of unhusked and husked grains and the linear regression between them were also calculated in the whole characters measured by comparing them.

To make clear the relations between the present material and other strains collected in Indonesia, comparison was made using the data obtained in the present and the previous[3,4] papers on habitat and the characters of the unhusked grains. In the latter, 2 strains were picked-up and adopted, *i. e.*, West Java (Stock No. W1285, abbreviated as WJ in the present paper) and Belandeau, Kalimantan (Stock No. W1293, abbreviated as BK in the present paper), which were directly collected there by the present author in 1963.

Results and Discussion

1. Locality and habitat

The wild rice was found at 9 kilometers northwest from Babat, Bojenegoro Prefecture, East Java, Indonesia. Babat is located at 73 kilometers west from Surabaya. There are paddy field on the east side of the main road and *SAWAH TAMBAK* on the west side of the main road in the large scale. Areas cultivating together rice and fish are called *SAWAH TAMBAK* as a general term. Paddy fields on the east side are separated with embankments at a right angles with the main road and constructed 50 cm lower than the main road. The embankments were 60 cm wide and between ditches, which were 90 cm wide and constructed 20 cm lower than the embankment. Moreover, water convolvulus called *KANGKUNG* (*Ipomoea aquatica* RORSK.) is growing there.

The wild rice was sporadically found at a boundary between ditch and embankment, but not found in other areas. In other words, the distributing area of wild rice was strictly limited.

Strain abbreviated as WJ was growing thickly in ponds and strain abbreviated as BK was found sporadically in open swamps. The latter was called at *PADI DJULUK* by the native peoples. In other words, it is said to be common plant species in this area. On the other hand, the strain in the present paper is almost unknown by the native peoples.

2. Abstract of plant morphology

Specimens collected have the following characteristics; plant 87 cm long, leaf blade 30 to 43 cm long and 1.5 cm wide, ligule 13 mm long, panicle 27 cm long and slightly spreading at maturity, spikelet easily shedding also at maturity, glume surface with distinct crosswise intersection rows of small tubercles, empty glume 2 mm long, grain dark brown, non-glutinous.

Based on the data obtained here, this strain of wild rice collected was detected to be *Oryza sativa* var. *spontanea* ROSCHEV.

3. Grain morphology

1) Practical values

Unhusked grain (Character Nos. 1 to 6)

The results are given in Table 1. Grains showed the following characteristics; 8.3 mm to 9.1 mm long, 3.1 mm to 3.5 mm wide, 1.7 mm to 2.0 mm thickness, 2.5 to 2.8 in ratio of length to width, 4.3 to 5.3 in ratio of length to thickness, 1.6 to 1.9 in ratio of width to thickness. Fig. 1 shows the relationship between length and width of the unhusked grains in mm.

In comparison with the present and the previous data in view of strain differenti-

	Length	Width	Thickness	L/W	L/T	W/T
Present	8.74	3.34	1.89	2.62	4.63	1.77
WJ	8.70	2.08	1.19	4.18	7.31	1.75
BK	8.14	2.14	1.30	3.80	6.26	1.64

Table 1. Morphological characters of the unhusked and the husked grains

	Character		No.	Average and its standard deviations	Range
Unhusked	Length		1	8.74±0.20 mm	9.05~8.30
	Width		2	3.34±0.09 mm	3.45~3.10
	Thickness		3	1.89±0.06 mm	1.95~1.70
	Length/Width		4	2.62±0.10	2.84~2.45
	Length/Thickness		5	4.63±0.18	5.29~4.33
	Width/Thickness		6	1.77±0.07	1.94~1.63
Husked	Length		11	5.93±0.09 mm	6.20~5.75
	Width		12	2.62±0.11 mm	2.80~2.40
	Thickness		13	1.57±0.07 mm	1.70~1.40
	Length/Width		14	2.27±0.11	2.50~2.11
	Length/Thickness		15	3.80±0.17	4.29~3.56
	Width/Thickness		16	1.68±0.11	1.87~1.50
Comparison	Length		21	0.68±0.01	0.70~0.66
	Width		22	0.78±0.02	0.82~0.71
	Thickness		23	0.83±0.02	0.86~0.76
	Length/Width		24	0.87±0.03	0.95~0.83
	Length/Thickness		25	0.82±0.03	0.89~0.77
	Width/Thickness		26	0.95±0.04	1.04~0.84
Area & Volume	Unhusked	Area	31	29.21±0.91 mm^2	30.88~27.28
		Volume	32	55.21±2.51 mm^3	60.22~50.49
	Husked	Area	33	15.56±0.70 mm^2	16.80~14.04
		Volume	34	24.36±1.56 mm^3	27.78~21.48
	Quotient	Area	35	0.53±0.02	0.57~0.47
		Volume	36	0.44±0.02	0.47~0.39

Quotient — Husked/Unhusked

Area — length × width, volume — length × width × thickness

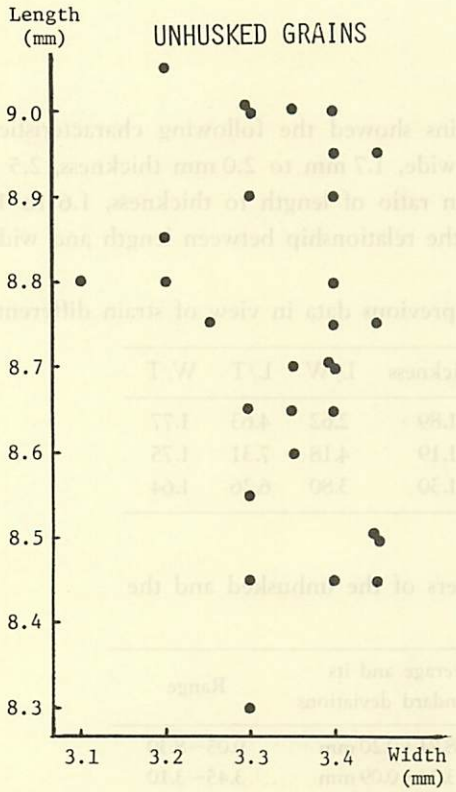


Fig. 1. Relation between length and width of unhusked grains in mm. Vertical axis ; length of grain ; abscissa ; width of grain.

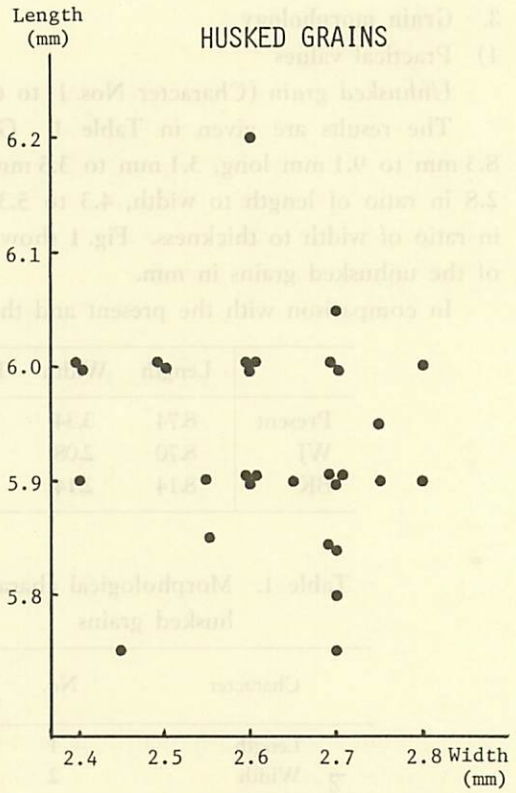


Fig. 2. Relation between length and width of husked grains in mm. Vertical axis ; length of grain ; abscissa ; width of grain.

ations, the following facts were ascertained. i) Values of length, width and thickness of the present strain were remarkably larger, *i. e.*, longer, wider and thicker, than that of WJ and BK. ii) According to the tripartite classification, almost grains of the present strain belong to B type, large type and *javanica* type. On the other hand, almost grains of WJ and BK belong to C type, slender type and *indica* type. iii) Values of L/W and L/T of the present strain were remarkably smaller than those of WJ and BK. iv) Value of W/T of the present strain was nearly the same as that of WJ and BK. v) In comparison with these results obtained here, the present strain would be located in the position relatively larger and wider status of wild rice in Indonesia.

Standard deviations, *i. e.*, intra-population's variations, of 3 characters were ascertained as follows ; length (0.20 in the present strain, 0.36 in WJ and 0.40 in BK), width (0.09, 0.15 and 0.13 in the same order) and thickness (0.06, 0.23 and 0.08 in the same order). In general, the strain having large and small standard deviations are said to be located in genetically unstable and stable statuses, respectively. So, the present strain is belonged to the latter one. It is thought that the present strain was looked upon having a long history after migrating here from another locality.

Husked grain (Character Nos. 11 to 16)

Grains showed the following characteristics; 5.8 mm to 6.2 mm long, 2.4 mm to 2.8 mm wide, 1.4 mm to 1.7 mm thickness, 2.1 to 2.5 in ratio of length to width, 3.6 to 4.3 in ratio of length to thickness and 1.5 to 1.9 in ratio of width to thickness. Fig. 2 shows the relationship between length and width of the husked grains in mm.

It was unexpectedly found that the standard deviations obtained in characters of husked grains were detected as nearly the same values as those of the unhusked grains excluding that of the length. This phenomenon is also found to be true in cultivated strain[5].

Comparison (Character Nos. 21 to 26)

Grains showed the following characteristics; 0.66 to 0.70 in length, 0.71 to 0.82 in width, 0.76 to 0.86 in thickness, 0.83 to 0.95 in ratio of length to width, 0.77 to 0.89 in ratio of length to thickness and 0.84 to 1.04 in ratio of width to thickness.

Comparative studies of data obtained in the previous characters have been looked upon as one of the most important characters for ecotypic differentiations in view of evolution. This character means biologically or agronomically the "grain fullness" in its capacity[7]. In evolutional and agronomical viewpoints, it may be said that the larger is the ratio of husked to unhusked grains in the respective characters, the more advanced is the evolutional state of respective strain. Values of length, width, and thickness were clearly found to be smaller than that of the cultivated strains[5,6].

Averages and ranges of variation became larger in the order of length, width and thickness of grain. In other words, grain length showed the lowest value but was most stable in view of the grain fullness, and was not affected by any environmental conditions. On the contrary, grain thickness showed the highest value but was unstable in view of the grain fullness. And grain width showed intermediate value both in the practical value and its stability. Such tendencies were found to be the same in cultivated rice strains[5,6] and wild rice species in India[7]. Then, the order found in length, width, and thickness in view of practical values and variation ranges are constant in the genus *Oryza*, regardless of species status.

Area and volume (Character Nos. 31 to 36)

Grains showed the following characteristics; 27.28 mm^2 to 30.88 mm^2 in area of unhusked grain, 50.49 mm^3 to 60.22 mm^3 in volume of unhusked grain, 14.04 mm^2 to 16.80 mm^2 in area of husked grain, 21.48 mm^3 to 27.78 mm^3 in volume of husked grain, 0.47 to 0.57 in quotient of area and 0.39 to 0.47 in quotient of volume.

The ears of rice plants have an ability of net photosynthesis. Maximum rate of net photosynthesis per one exposed surface has been fixed as 1-2 mg CO_2/dm^2 (100 spikelets)/h[10]. Grain volume has been looked upon as an end product. Then, studies on surface and volume of grains were regarded as important characters in view of strain differentiations. So, these characters were employed here as a new method. However, these could not be fully explained at present, and further studies in this characters should soon be performed.

2) Relations between the respective 2 characters

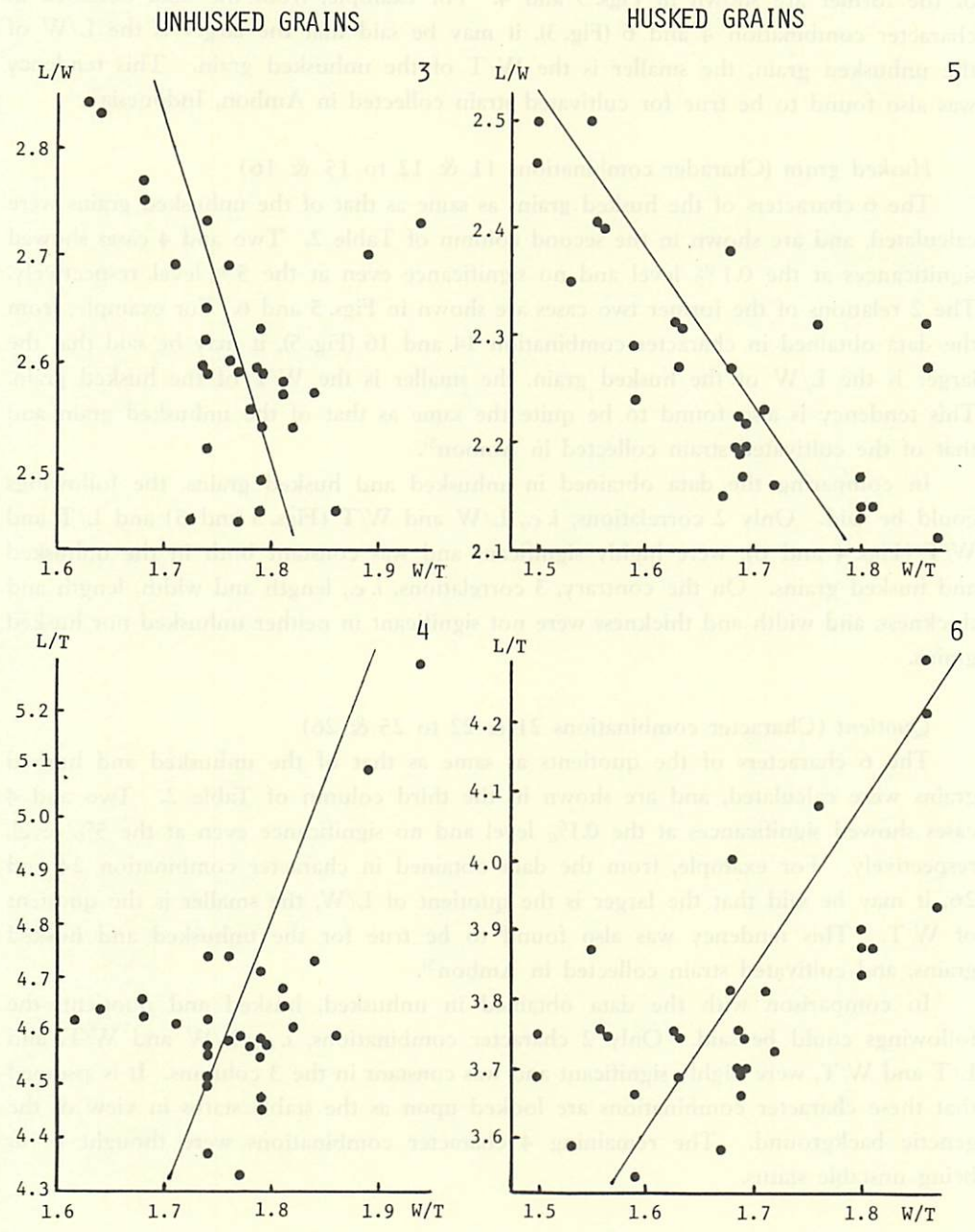
Unhusked grain (Character combinations 1 & 2 to 5 & 6)

To make clear the 3 relationships between length and width, length and thickness, width and thickness, as well as 3 components, *i. e.*, ratios of length to width (abbreviated as L/W in Table 2) and of length to thickness (L/T), of length to width (L/W) and of width to thickness (W/T), of length to thickness (L/T) and of width to thickness (W/

Table 2. Correlation coefficient and linear regression of the former character (Y) on the latter character (X) for 27 character-combinations

	Character	Nos.	Correlation coefficient	Linear regression
Unhusked	Length and Width	1 & 2	-0.2222	-
	Length and Thickness	1 & 3	-0.0125	-
	Width and Thickness	2 & 3	0.1453	-
	L/W and L/T	4 & 5	0.5181**	Y=0.920X+2.219
	L/W and W/T	4 & 6	-0.4730**	Y=-0.304X+2.565
	L/T and W/T	5 & 6	0.5021**	Y=0.182X+0.928
Husked	Length and Width	11 & 12	-0.0969	-
	Length and Thickness	11 & 13	0.1849	-
	Width and Thickness	12 & 13	-0.0135	-
	L/W and L/T	14 & 15	0.0615	-
	L/W and W/T	14 & 16	-0.7116***	Y=-0.686X+3.234
	L/T and W/T	15 & 16	0.6552***	Y=0.410X+0.126
Quotient	Length and Width	21 & 22	-0.0464	-
	Length and Thickness	21 & 23	0.0147	-
	Width and Thickness	22 & 23	-0.0936	-
	L/W and L/T	24 & 25	0.1053	-
	L/W and W/T	24 & 26	-0.6893***	Y=-0.978X+1.795
	L/T and W/T	25 & 26	0.6366***	Y=0.985X+0.140
Comparison	Length	1 & 11	0.7747***	Y=0.356X+2.825
	Width	2 & 12	0.6870***	Y=0.884X−0.333
	Thickness	3 & 13	0.7220***	Y=0.885X−0.108
	L/W	4 & 14	0.6712***	Y=0.718X+0.386
	L/T	5 & 15	0.6581***	Y=0.611X+0.970
	W/T	6 & 16	0.6763***	Y=1.085X−0.238
Ratio	Area	31 & 33	0.6150***	Y=0.471X+1.795
	Volume	32 & 34	0.7389***	Y=0.461X−1.112
	Quotient	35 & 36	0.6811***	Y=0.685X+0.075

L/W—Length/Width, L/T—Length/Thickness, W/T—Width/Thickness
Area—length × width, volume—length × width × thickness
***, ** — significant at 0.1 % and 1 % levels, respectively
Quotient — Husked/Unhusked



Figs. 3 to 6. Relations between the 2 characters in the unhusked and the husked grains. Figs. 3 and 4: unhusked grains; Figs. 5 and 6: husked grains, Figs. 3 and 5: L/W and W/T, Figs. 4 and 6: L/T and W/T.

T), correlation coefficients and linear regressions between them were calculated, and are shown in the first column of Table 2. Three and other 3 cases showed significances at the 1% level and no significance even at the 5% level, respectively. The 2 relations

of the former are shown in Figs. 3 and 4. For example, from the data obtained in character combination 4 and 6 (Fig. 3), it may be said that the larger is the L/W of the unhusked grain, the smaller is the W/T of the unhusked grain. This tendency was also found to be true for cultivated strain collected in Ambon, Indonesia[5].

Husked grain (Charader combinations 11 & 12 to 15 & 16)

The 6 characters of the husked grains as same as that of the unhusked grains were calculated, and are shown in the second column of Table 2. Two and 4 cases showed significances at the 0.1% level and no significance even at the 5% level, respectively. The 2 relations of the former two cases are shown in Figs. 5 and 6. For example, from the data obtained in character combination 14 and 16 (Fig. 5), it may be said that the larger is the L/W of the husked grain, the smaller is the W/T of the husked grain. This tendency is also found to be quite the same as that of the unhusked grain and that of the cultivated strain collected in Ambon[5].

In comparing the data obtained in unhusked and husked grains, the followings could be said. Only 2 correlations, *i. e.*, L/W and W/T (Figs. 3 and 5) and L/T and W/T (Figs. 4 and 6), were highly significant and was constant both in the unhusked and husked grains. On the contrary, 3 correlations, *i. e.*, length and width, length and thickness, and width and thickness were not significant in neither unhusked nor husked grains.

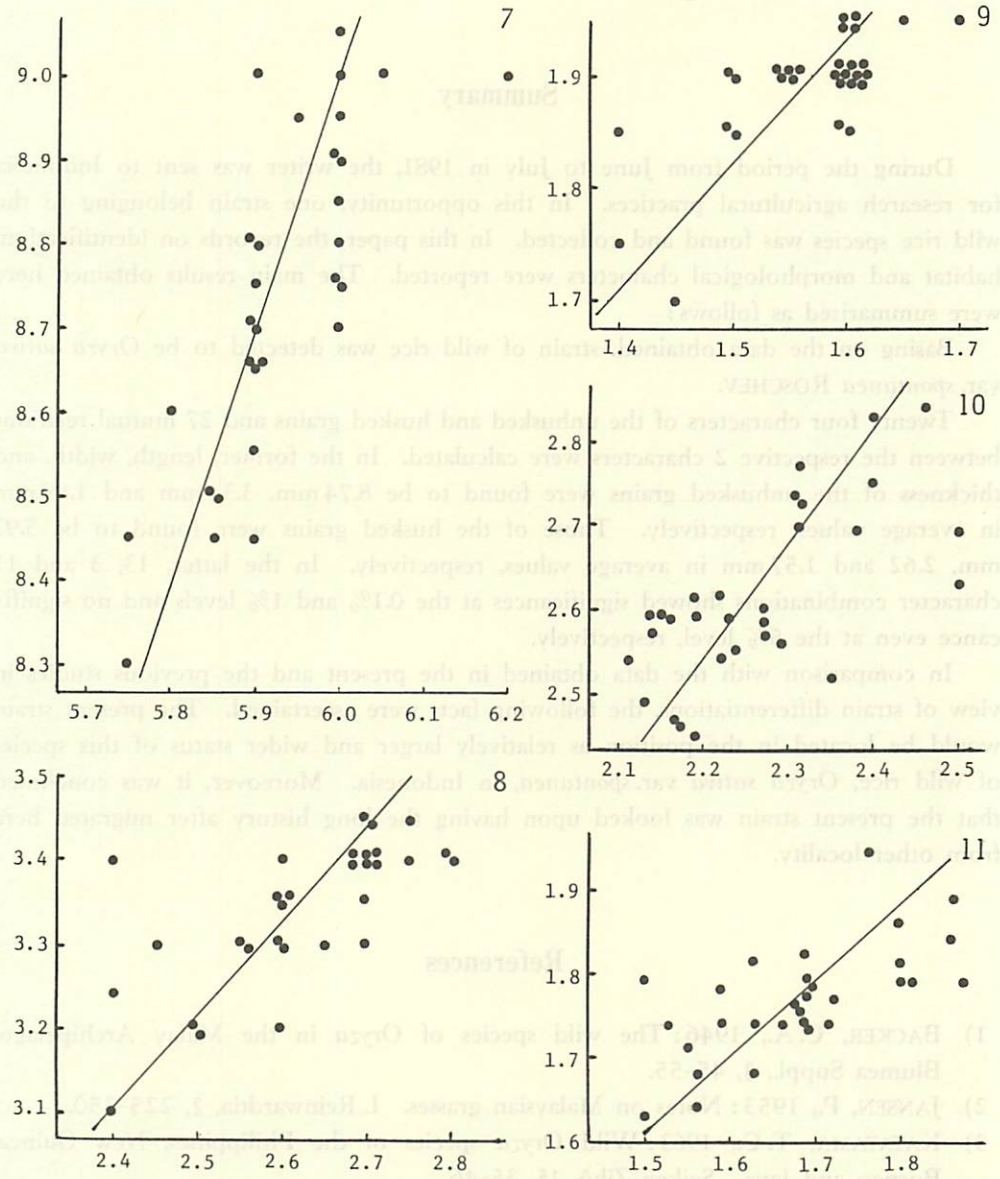
Quotient (Character combinations 21 & 22 to 25 & 26)

The 6 characters of the quotients as same as that of the unhusked and husked grains were calculated, and are shown in the third column of Table 2. Two and 4 cases showed significances at the 0.1% level and no significance even at the 5% level, respectively. For example, from the data obtained in character combination 24 and 26, it may be said that the larger is the quotient of L/W, the smaller is the quotient of W/T. This tendency was also found to be true for the unhusked and husked grains, and cultivated strain collected in Ambon[5].

In comparison with the data obtained in unhusked, husked and quotient, the followings could be said. Only 2 character combinations, *i. e.*, L/W and W/T, and L/T and W/T, were highly significant and was constant in the 3 columns. It is assumed that these character combinations are looked upon as the stable status in view of the genetic background. The remaining 4 character combinations were thought of as being unstable status.

Comparison (Character combinations 1 & 11 to 6 & 16)

To make clear the relations between unhusked and husked grains in view of the six characters, correlation coefficients and linear regressions between them were calculated, and are shown in the fourth column of Table 2. All of them showed significances at the 0.1% level. The 5 relations of them are shown in Figs. 7 to 11. For example, from the data obtained in character combination 1 and 11 (Fig. 7), it may be said that the longer is the length of the unhusked grain, the longer is the length of the husked grain. This tendency is also found in the cultivated rice in Ambon[5].



Figs. 7 to 11. Relations between the unhusked and the husked grains. Vertical axis; unhusked grain, abscissa; husked grain. 7: length in mm, 8: width in mm, 9: thickness in mm, 10: L/W, 11: W/T.

Ratio (Character combinations 31 & 33 to 35 & 36)

To make clear the relations between unhusked and husked grains with regard to area and volume, correlation coefficients and linear regressions between them were calculated, and are shown in the last column of Table 2. All of them showed significances at the 0.1% level. For example, from the data obtained in character combination 31 and 33, it may be said that the wider is the area of the unhusked grain, the wider

is the area of the husked grain.

Summary

During the period from June to July in 1981, the writer was sent to Indonesia for research agricultural practices. In this opportunity, one strain belonging to the wild rice species was found and collected. In this paper, the records on identification, habitat and morphological characters were reported. The main results obtained here were summarized as follows:

Basing on the data obtained, strain of wild rice was detected to be *Oryza sativa* var. *spontanea* ROSCHEV.

Twenty four characters of the unhusked and husked grains and 27 mutual relations between the respective 2 characters were calculated. In the former, length, width, and thickness of the unhusked grains were found to be 8.74 mm, 3.34 mm and 1.89 mm in average values, respectively. Those of the husked grains were found to be 5.93 mm, 2.62 and 1.57 mm in average values, respectively. In the latter, 13, 3 and 11 character combinations showed significances at the 0.1% and 1% levels and no significance even at the 5% level, respectively.

In comparison with the data obtained in the present and the previous studies in view of strain differentiations, the following facts were ascertained. The present strain would be located in the position as relatively larger and wider status of this species of wild rice, *Oryza sativa* var. *spontanea*, in Indonesia. Moreover, it was concluded that the present strain was looked upon having the long history after migrated here from other locality.

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